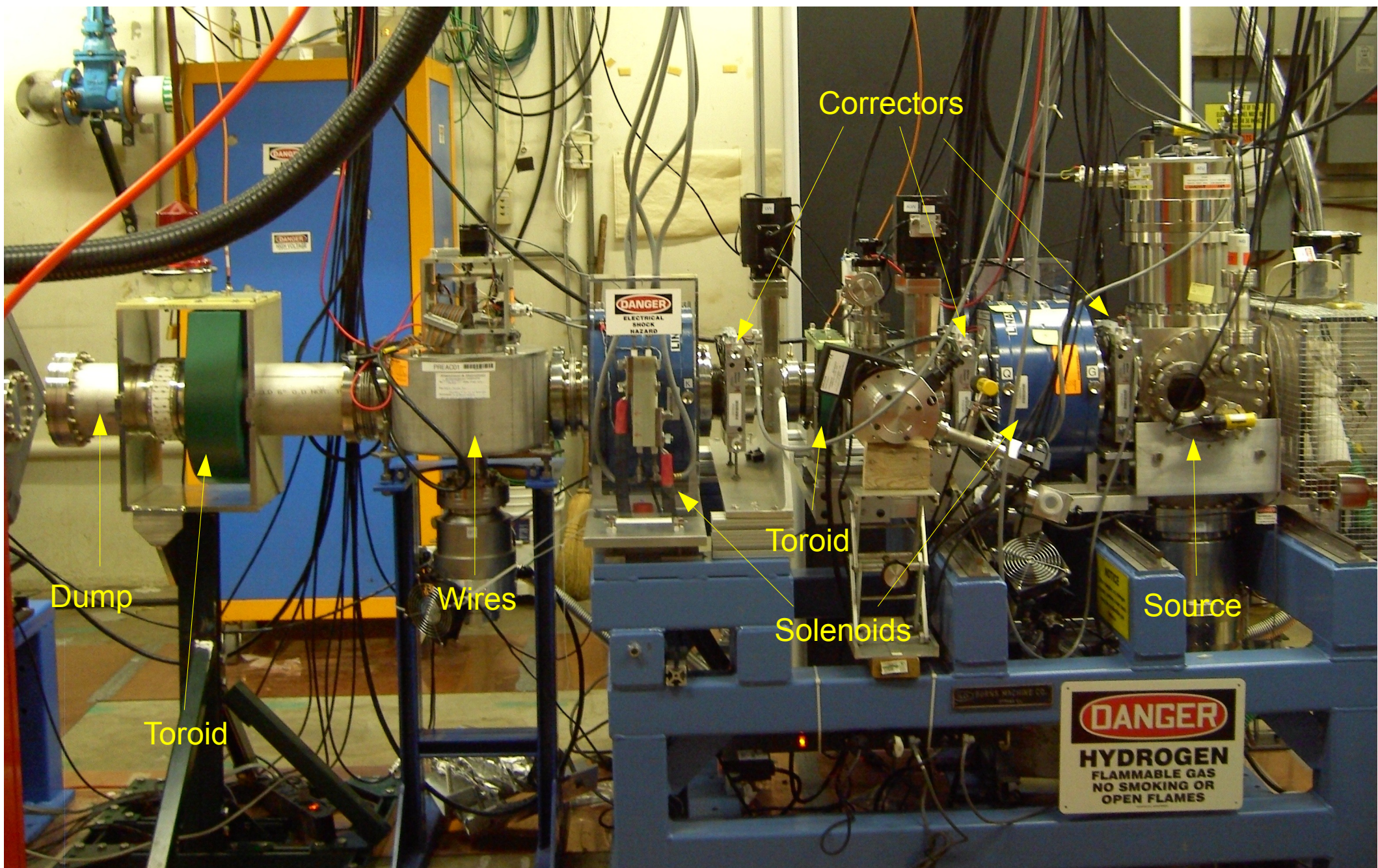
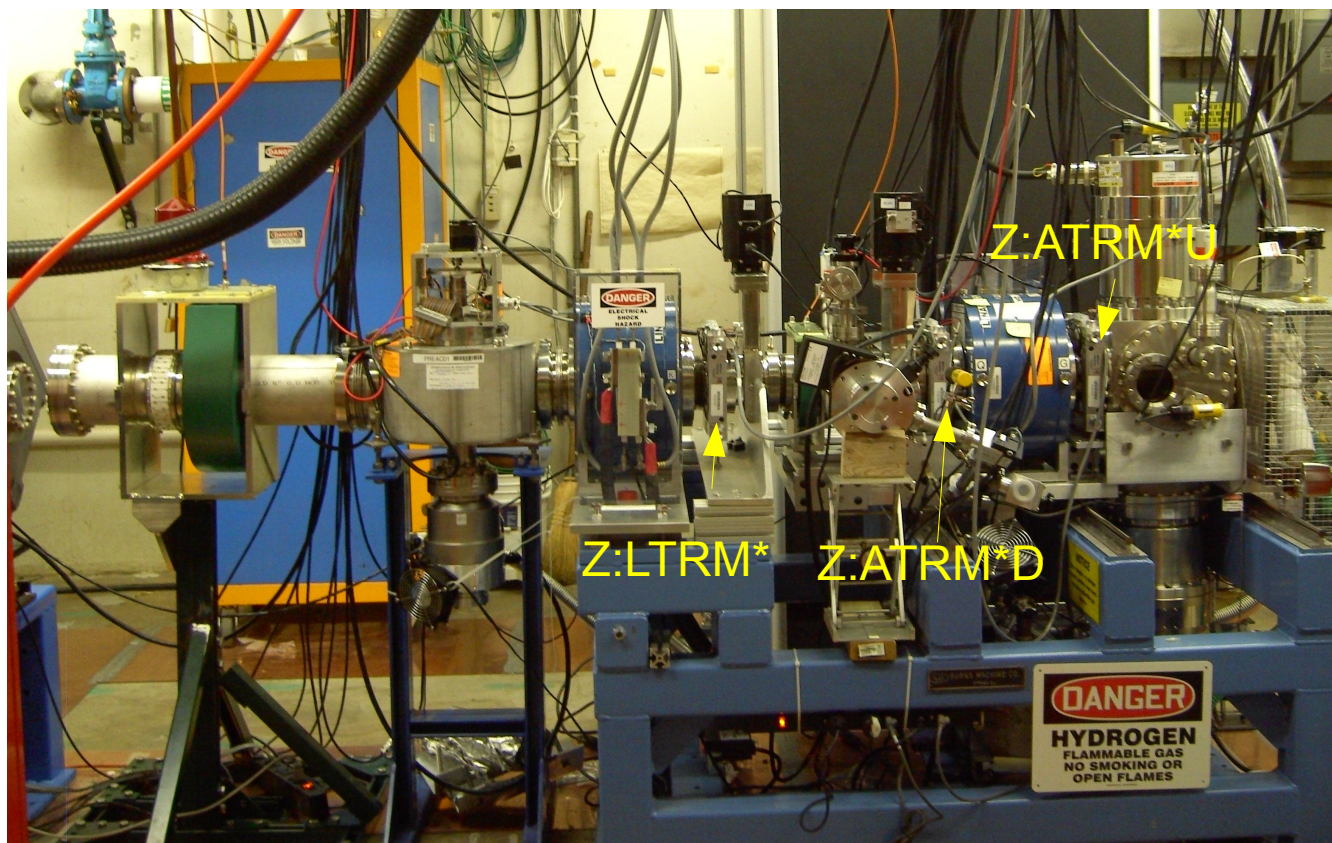


LEBT Beam Measurements

C.Y. Tan, P. Karns, D. Bollinger
04 Jan 2012

The LEBT

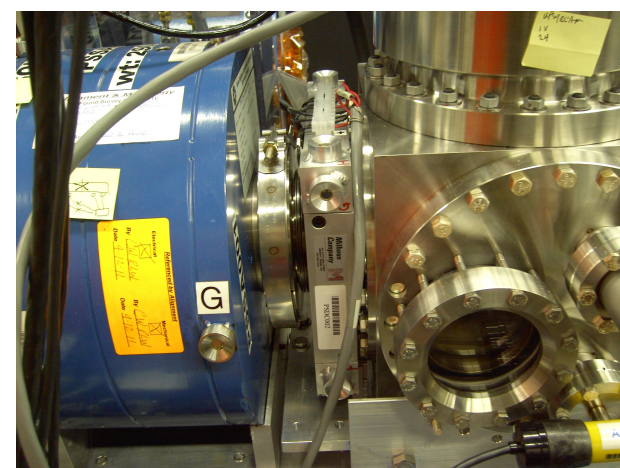
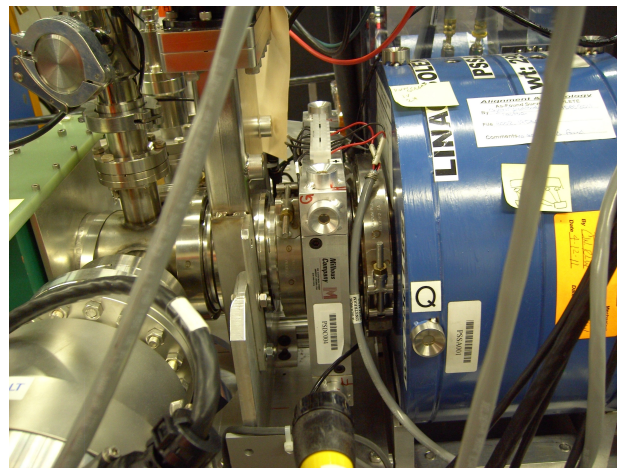
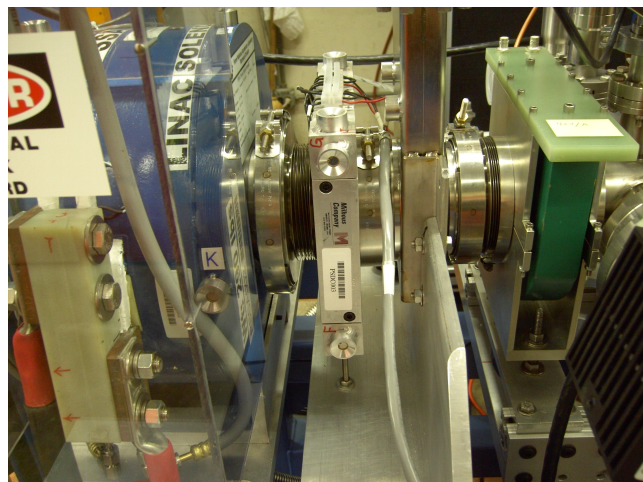




Z:LTRM*

Z:ATRM*D

Z:ATRM*U



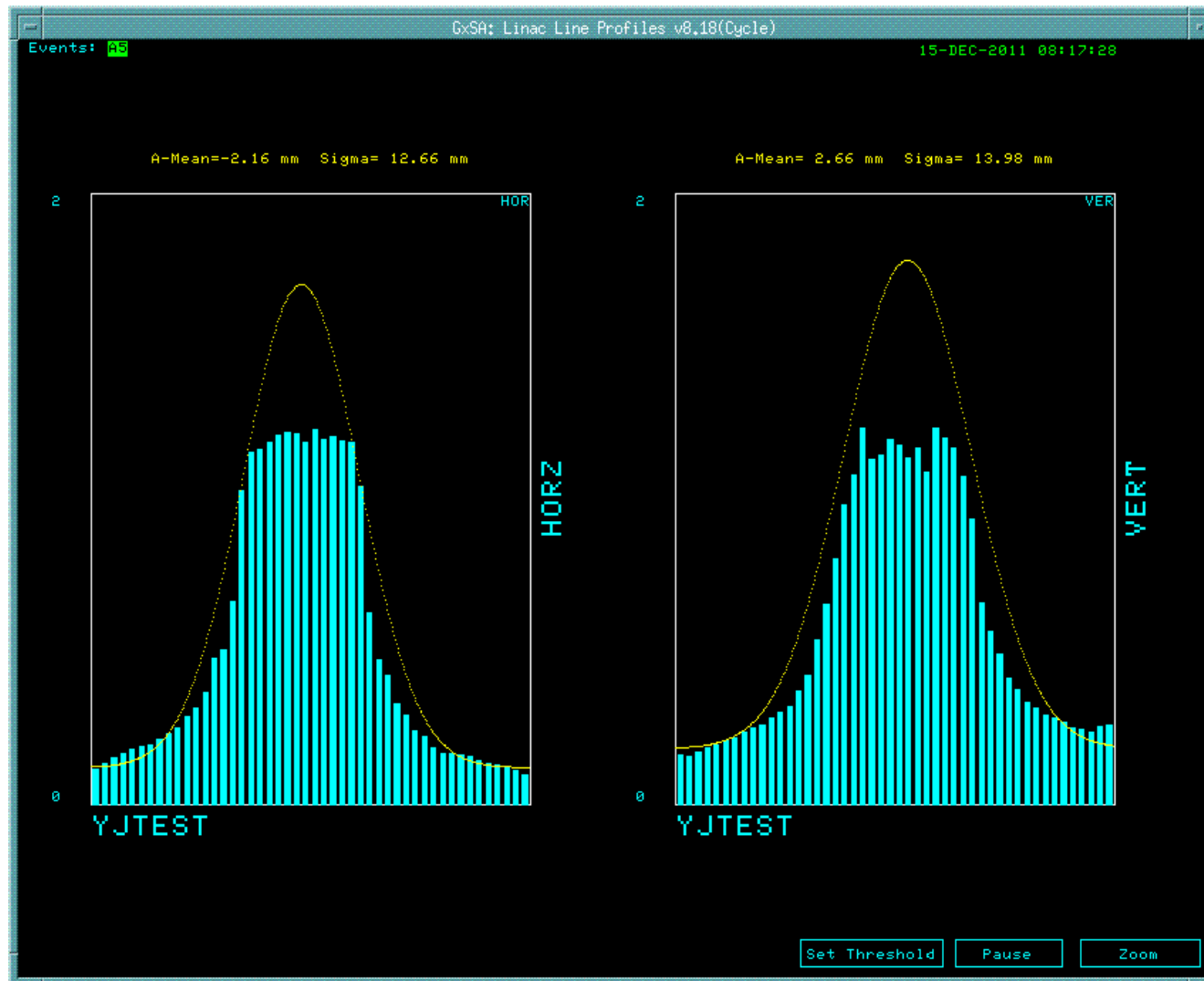
Goal and Method

- Understand and model the LEBT line so that we can paint the strike zone when the RFQ is connected.
- Calculate
 - Corrector strengths as a function of current.
 - Solenoid focusing strength as a function of corrector current.
- Cleanest way is to have downstream solenoid OFF.
 - But we have problems with vertical wires in this case.

Elements to be calibrated

- 2 Solenoids
 - Sol1, Sol 2
- 3 sets of horz and vert correctors
 - Z:ATRMHU, Z:ATRMVU
 - Z:ATRMHD, Z:ATRMHD
 - Z:LTRMH, Z:LTRMV

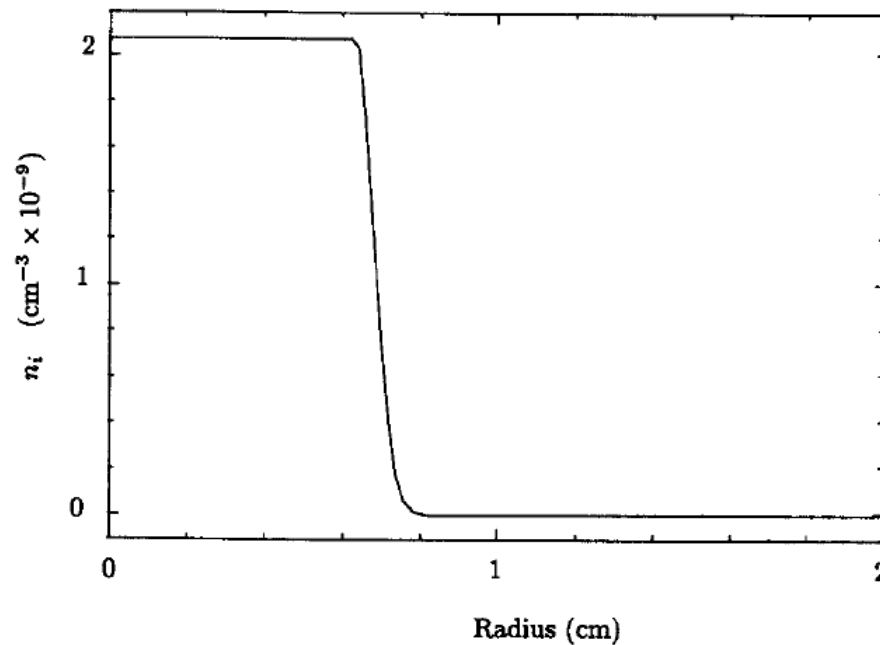
Interesting Beam Features on the Wire



Sol 1 = 398A,
Sol 2 = 261 A

Beam profile is **not**
gaussian. It is quite flat
at the top.

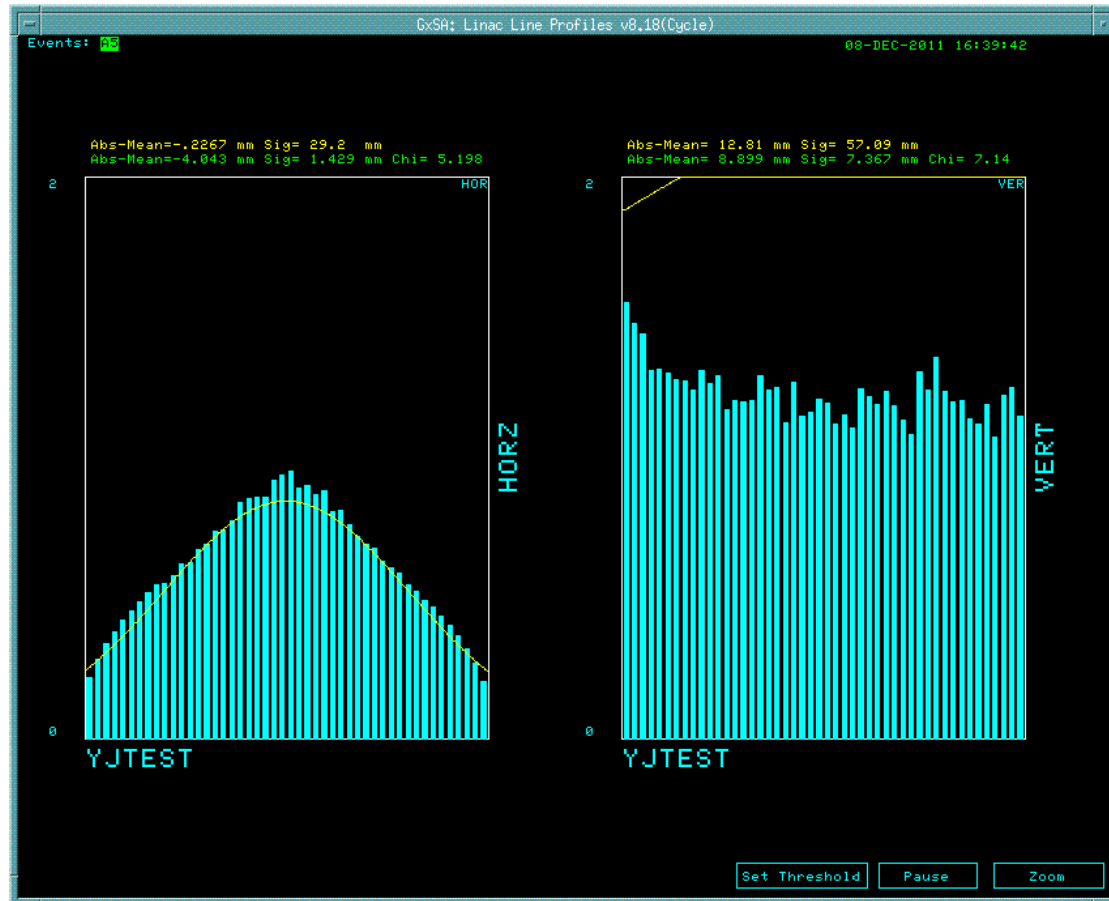
Flatness is REAL and predicted by Theory!



“Approach of a gas focusing system to steady state”, E. Horowitz et al, Phys. Fluids B 1 (6), June 1989.

“Generalized Three-Dimensional Equations for the Emittance and Field Energy of High-Current Beams in Periodic Focusing Structures”, I. Hofmann & J. Struckmeier, Part. Acc. 1987, Vol 21, pp 69-98.

Vertical Wires Hampered by Backscattering



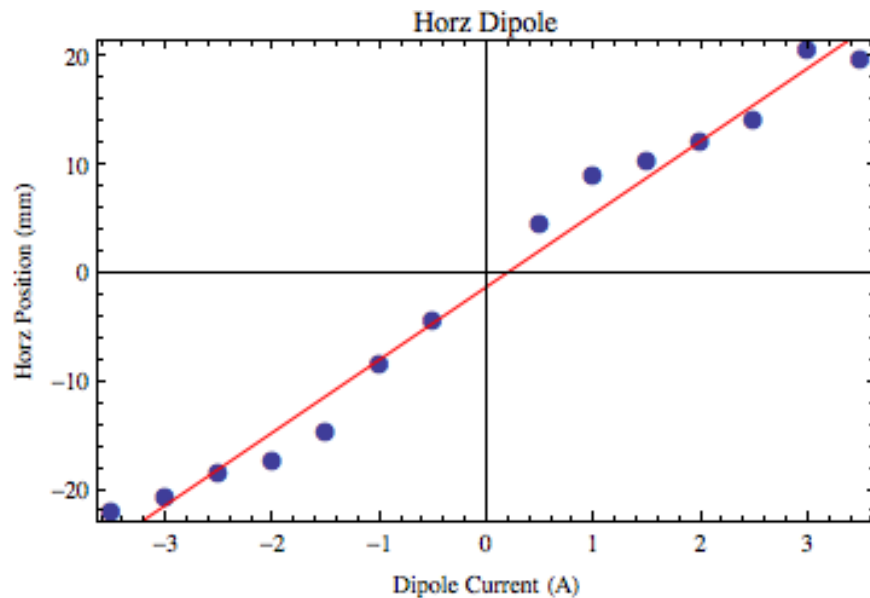
Sol 1 = 455 A.

Sol 2 = 0.

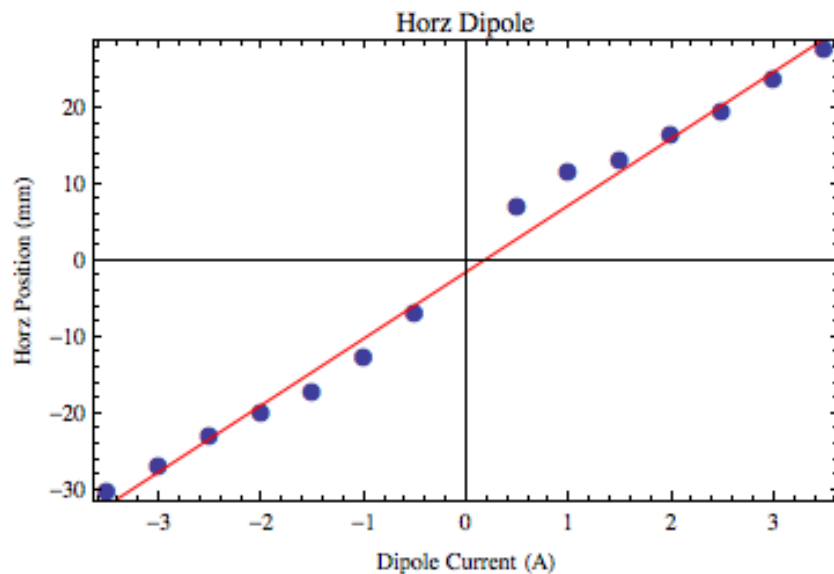
Beam is focused on wires with just the first solenoid.

Therefore, we can calibrate horizontal with solenoid 1 off but have to have solenoid 2 ON otherwise.

Horizontal Calibrations of Z:LTRMH and Z:ATRMHD



Z:LTRMH: 0.69 deg/A



Z:ATRMHD: 0.48 deg/A.
Note: affected by
upstream focusing.

TD Measurements

magnet	PSDC001		PSDC002		PSDC003		PSDC004		PSDC005	
	Horizontal <u>Bdl</u> (gauss·m)	Vertical <u>Bdl</u> (gauss·m)	Horizontal <u>Bdl</u> (gauss·m)	Vertical <u>Bdl</u> (gauss·m)	Horizontal <u>Bdl</u> (gauss·m)	Vertical <u>Bdl</u> (gauss·m)	Horizontal <u>Bdl</u> (gauss·m)	Vertical <u>Bdl</u> (gauss·m)	Horizontal <u>Bdl</u> (gauss·m)	Vertical <u>Bdl</u> (gauss·m)
@ -2 A	8.93	8.73	9.13	8.80	9.06	8.75	8.95	8.74	9.03	8.84
@+2 A	7.36	7.97	7.59	8.05	7.62	7.91	7.48	7.95	7.54	7.99

Z:ATRM*U

Z:LTRM*

Z:ATRM*D

Bdl's are not symmetric about +/-2A. (residual magnetization effect)

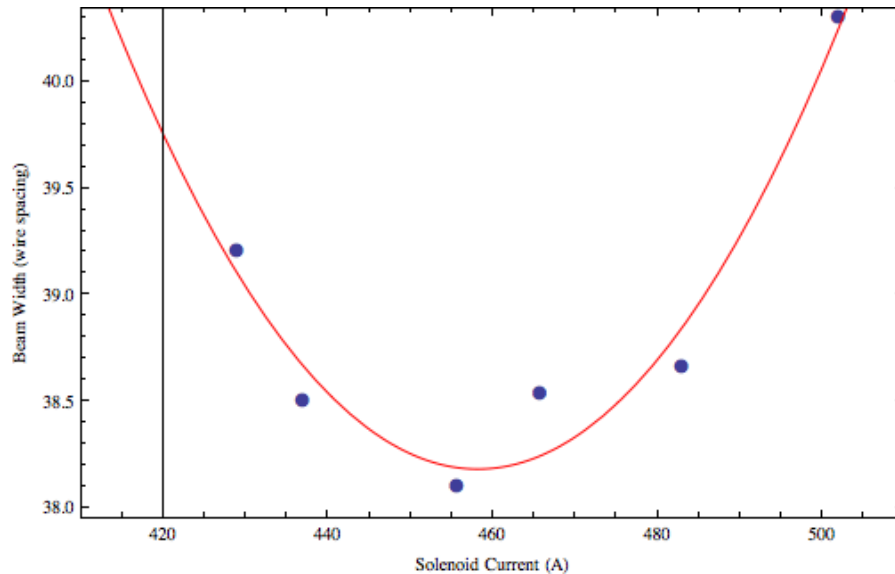
$Z:ATRMHD/Z:LTRMH @2A = 8.95/9.06 = 0.99$

Measured with beam $\text{deg}/A = 0.48/0.69 = 0.70$

Focusing of solenoid affects apparent strength of trims.

In simulations, assume that the strengths are the same in both planes. For simplicity, adopt Z:LTRMH values for all trims.

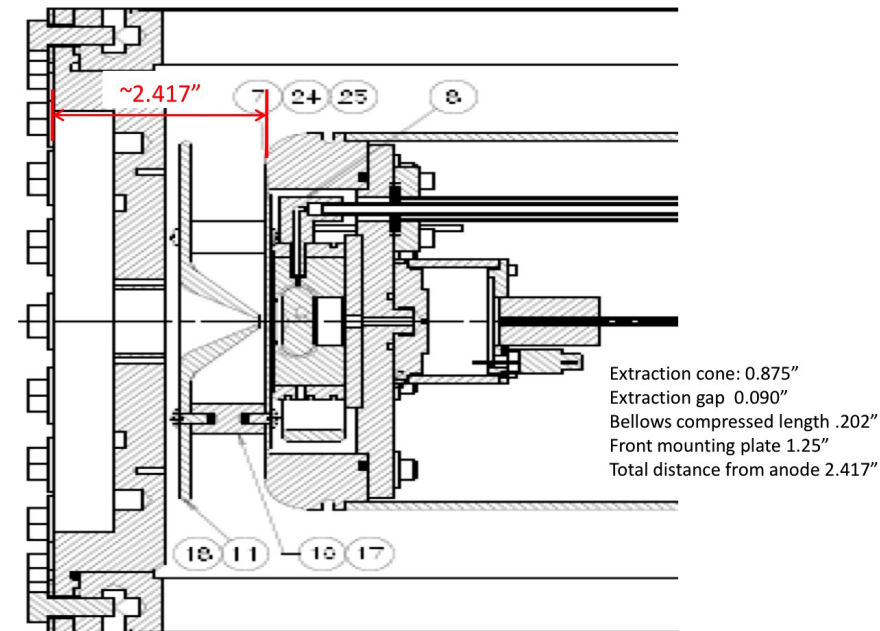
Solenoid 1 Focusing on Wires



460A is minimum size.

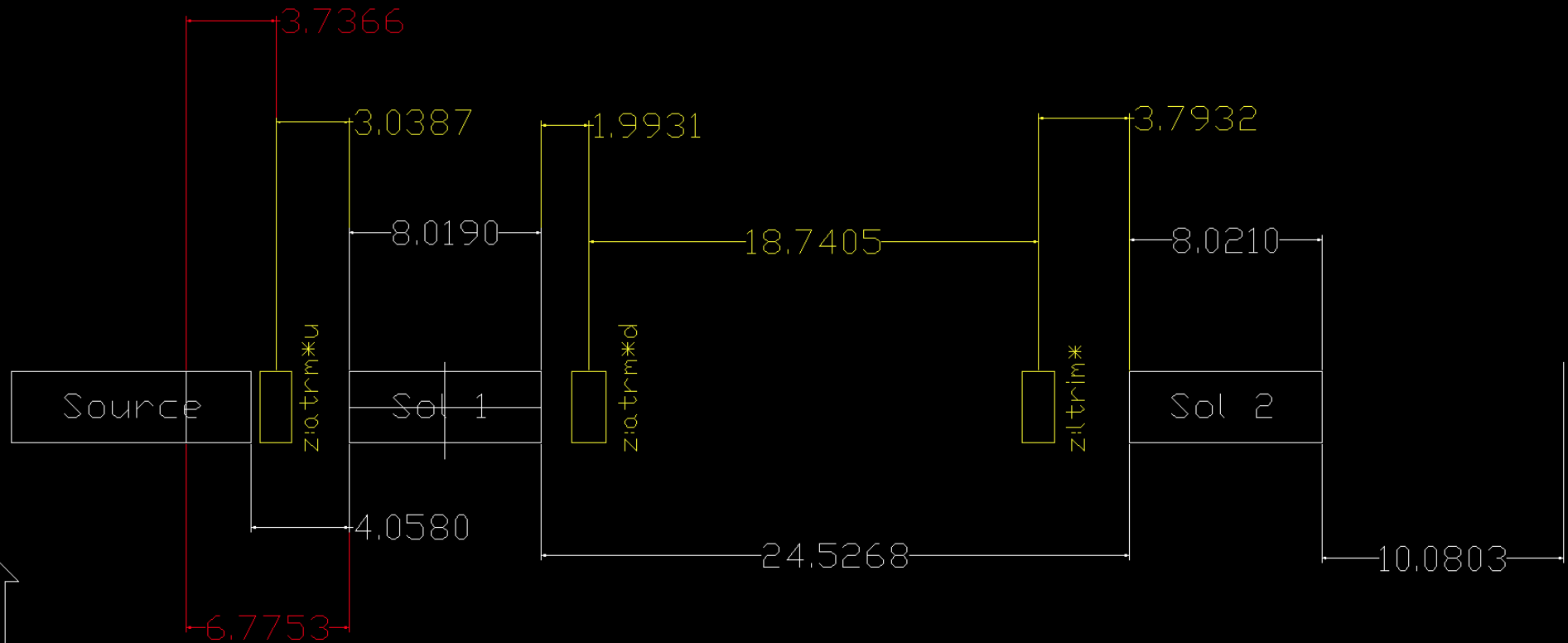
From this value can calculate object distance, given image distance and focal length (calculated from formula with measured $\int B^2 dz = 22 \text{ cm}$)

Image distance is about 7cm=2.75 inches from the edge of the cube.



Modelling the line ...

After re-alignment on 19 Dec 2011



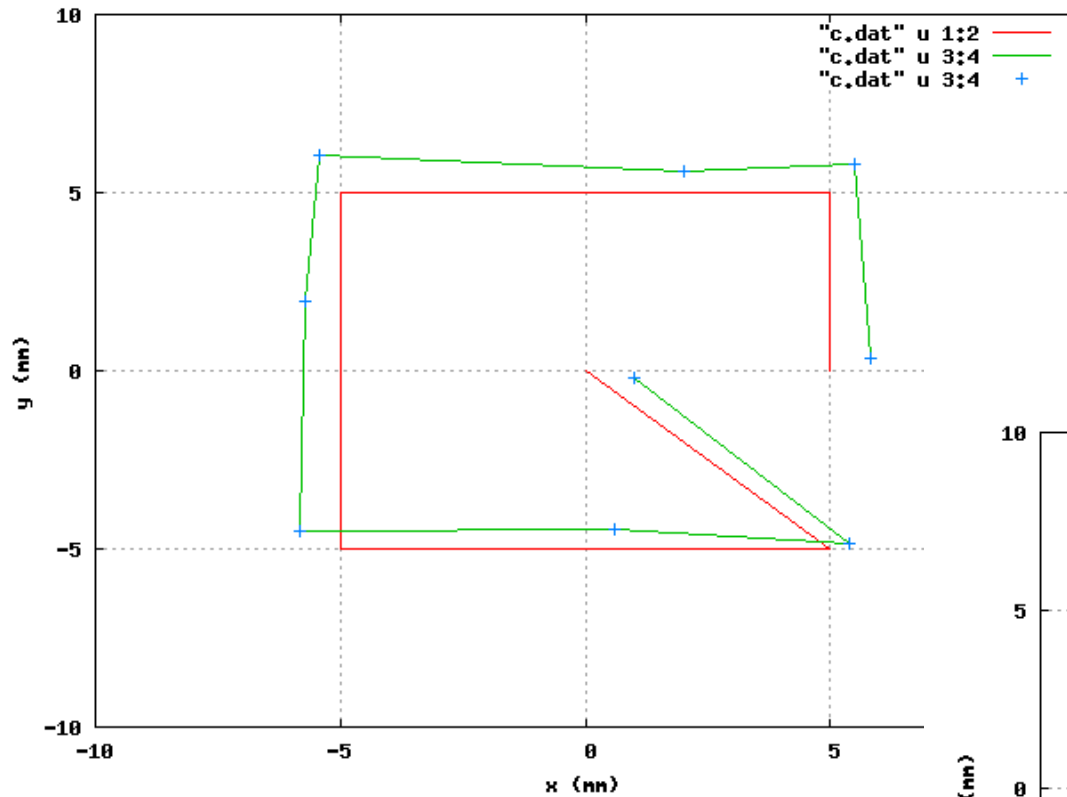
Use transport matrices.

(1) Hard edge model for solenoids. (Does not work very well!)

(2) Corrector calibrations

Painting the Strike Zone (Successful BUT ...)

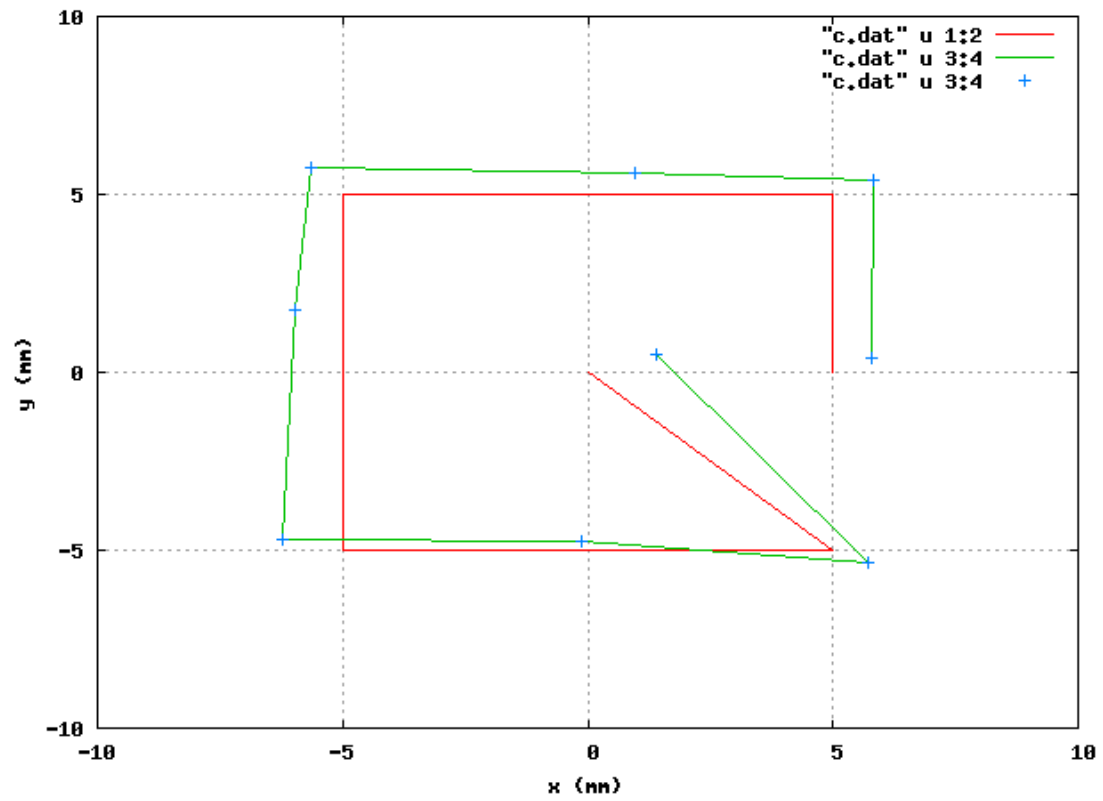
Painting the corners



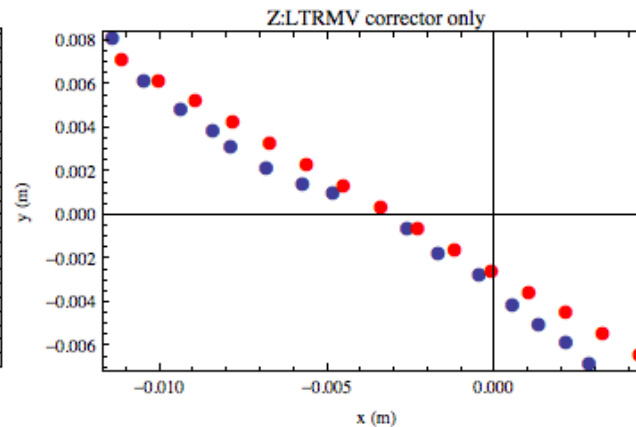
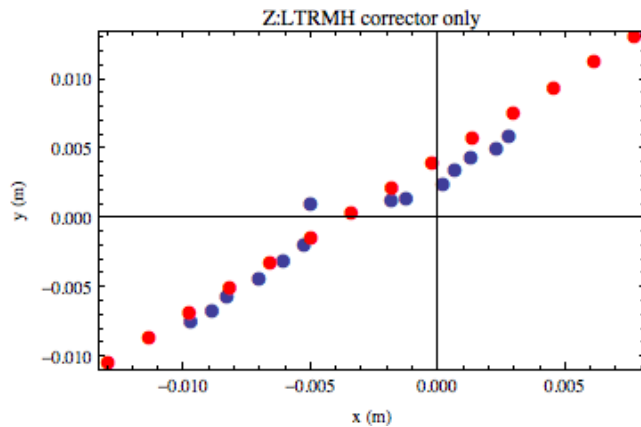
sol1=413A, sol2=380A

sol1=454A, sol2=414A

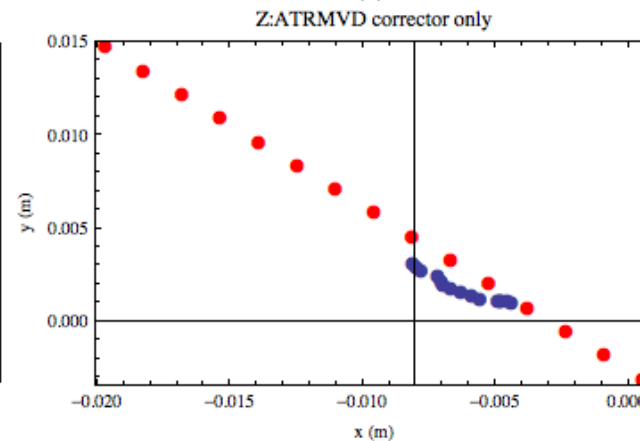
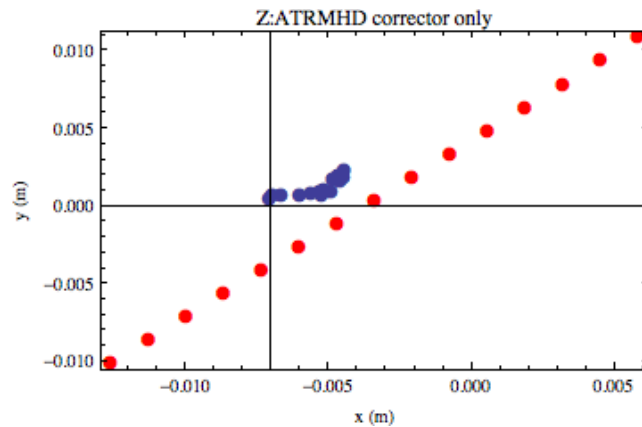
Painting the corners



Without extra lens at the end of solenoid 2

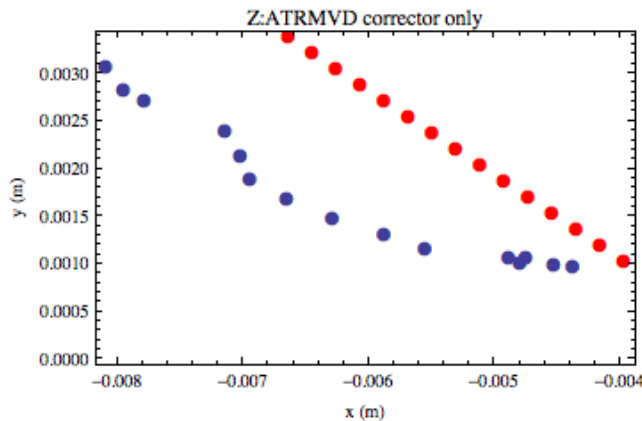
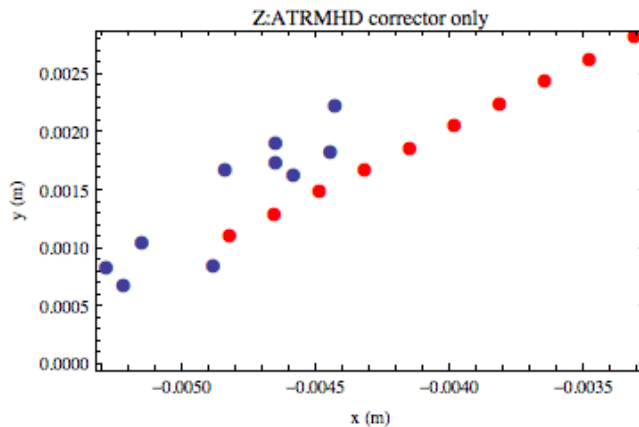
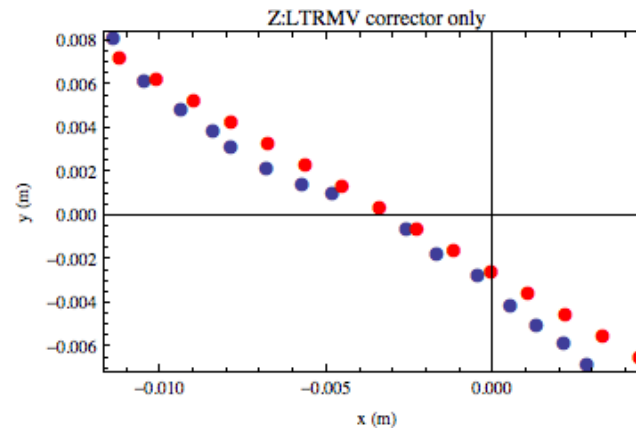
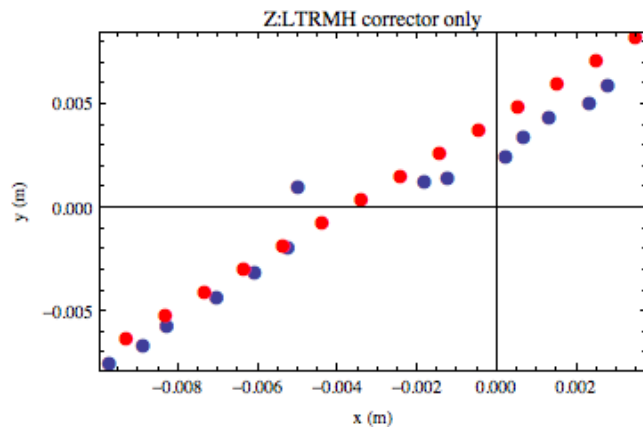


Z:LTRM* fit going through solenoid 2 looks ok.



DOES NOT FIT
Z:ATRM*D at all!

Addition of extra lens gives much better results



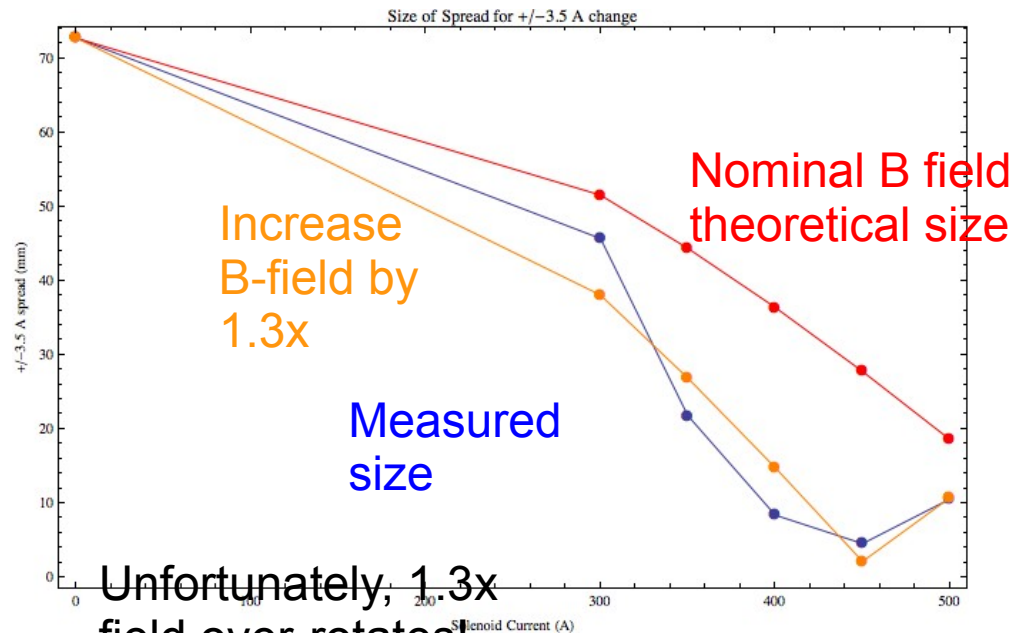
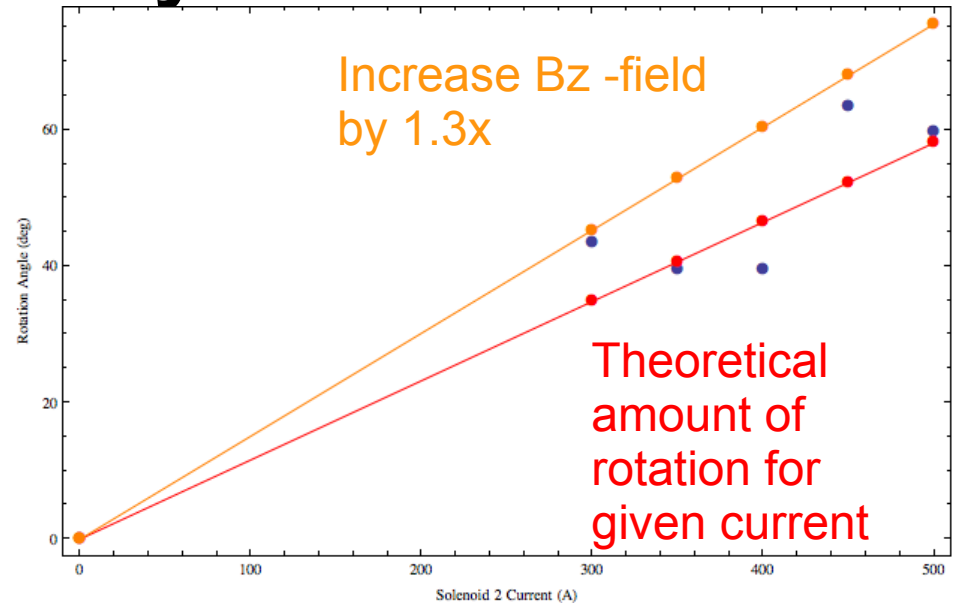
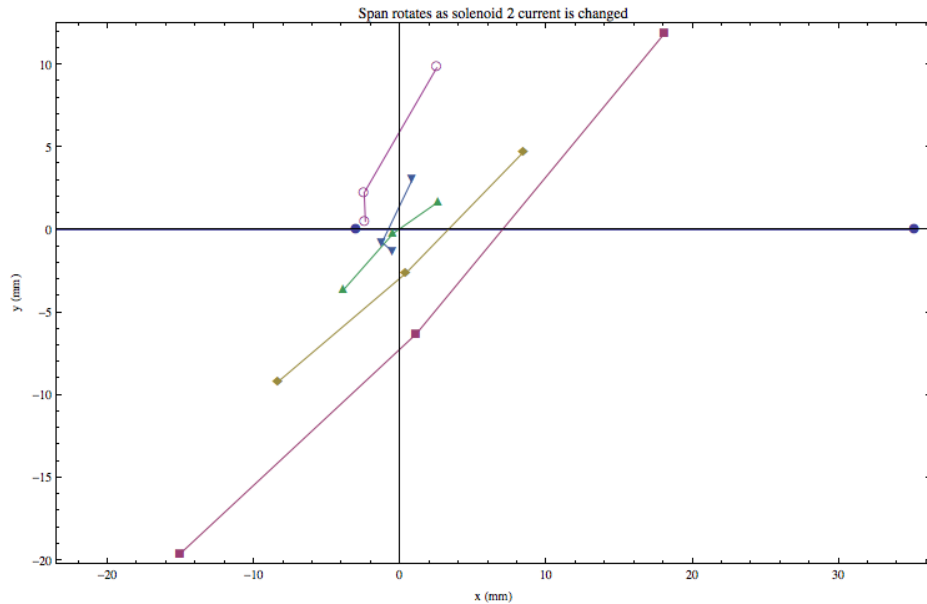
Fits better, (note scale), but not perfect.

Lens has focal length of 33 cm

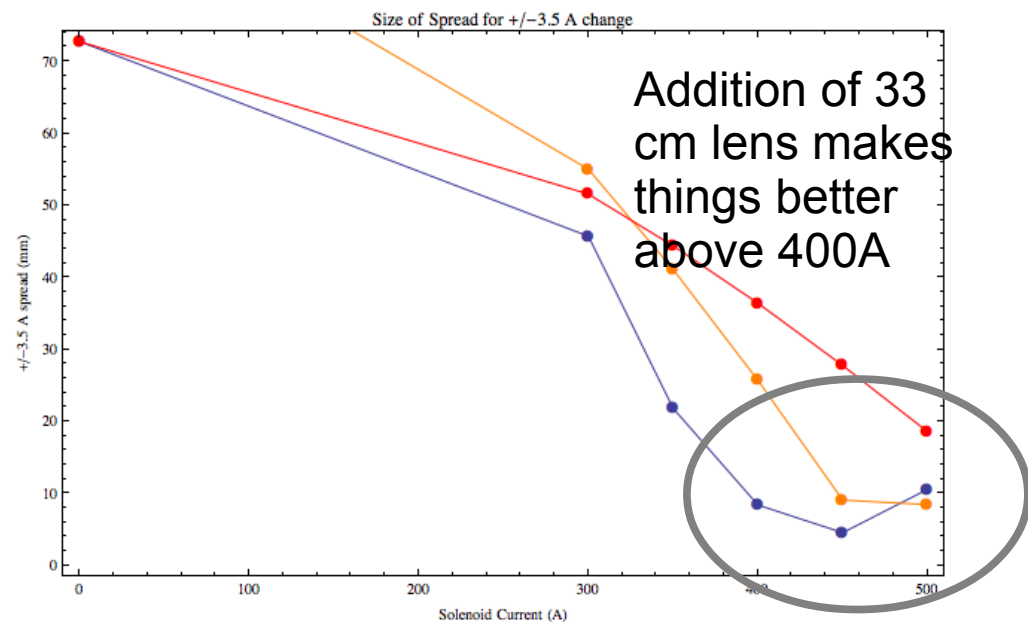
What does addition of extra lens mean?

- More gas focusing than expected?
 - Function of beam size? Not seen when solenoid 2 is off. This is unlikely to be the cause.
 - Addition of Einzel lens chopper will show whether gas focusing is the cause.
- Poor modelling of the solenoid
 - Hard edge model → soft edge model does not fix problem.
 - Need to to Runge-Kutta particle tracking to see if this fixes problem.

Solenoid Effects: Measurement and Theory



Unfortunately, 1.3x field over-rotates!



Conclusion

- Model is good enough for now to place the beam where we want
- However in the longer term
 - Improve with better solenoid model (Pat is going to work on this)
 - Check that Runge Kutta tracking produces the measured results.
 - Einzel lens experiments will preclude gas-focusing as the source of the problem.